

**DEVELOPMENT OF DROUGHT RISK MAP OF
ZAYANDEHRUD DAM CATCHMENT USING
WATER RESOURCE APPROACH PROCESS**

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CATCHMENT USING WATER RESOURCE APPROACH PROCESS**

by

YOUSEF MORADI SHAHGHARYEH

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degree of Doctor of Philosophy**

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STATEMENT

This thesis is submitted for the degree of Doctor of Philosophy at the Universiti Sains Malaysia. It is the result of my own work and contains not anything which is the outcome of work done in association except where precisely specified in the text.

Yousef Moradi Shahgharyeh

DEDICATION

This thesis is dedicated to the soul of my late Mother and my Father for their endless inspiration and moral support during all my life, to my wife for patience and stands with the long my absence, to our children in who's their innocent look.

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LIST OF ABBREVIATIONS

| | |
|-------|---|
| AR | Autoregressive |
| BMI | Bhalme and Mooley Index |
| CMI | Crop Moisture Index |
| CN | Curve Number |
| D | Drought Duration |
| DEM | Digital Elevation Model |
| DGPS | Differential Global Positioning System |
| DM | Drought Magnitude |
| DRA | Drought Risk Assessment |
| DTMs | Digital Terrain Models |
| EARC | Esfahan Agricultural Research Centre |
| ENSO | El Nino and Southern Oscillation |
| EVM | Extreme Value Model |
| GAHP | Gamma Highest Probability |
| GIS | Geographical Information System |
| GS | Ghalehshahrokh Station |
| GSI | Geological survey of Iran |
| IA | Integrated Assessment |
| IAERI | Iranian Agricultural Engineering Research Institute |
| IAMs | Integrated Assessment Models |
| IBWT | Interbasin Water Transfer |
| ICM | Integrated catchment management |
| IDNDR | International Decade for Natural Disaster Reduction |
| IPCC | Intergovernmental Panel on Climate Change(|
| IWMI | International Water Management Institute |

| | |
|-------|---|
| IWRM | Integrated Water Resource Management |
| LCK | L-Coefficient of Kurtosis |
| LC-LU | Land Cover and Land Use |
| LCs L | L-Coefficient of Skewness |
| LCv | L-Coefficient of variation |
| LiDAR | Light Detection and Ranging |
| LMRDs | L-Moment Ratio Diagrams |
| LR | Langan River |
| MDP | Maximum Daily Precipitation |
| MLE | Maximum Likelihood Estimates |
| MRRA | Multivariate Regional Regression Analysis |
| MRRMs | Multivariate Regional Regression Models |
| MSE | Mean Squared Error |
| NCDC | National Climatic Data Centre |
| NDMC | National Drought Mitigation Centre |
| NRI | National rainfall index |
| PA | Precipitation anomaly |
| PAC | Precipitation anomaly classification |
| PDSI | Palmer Drought Severity Index |
| PN | Percentage of normal |
| PNP | Percent of Normal Precipitation |
| PR | Pelasjan River |
| RDI | Reclamation drought index |
| RFFA | Regional Flood Frequency Analysis |
| RS | Remote Sensing |
| RVI | Rainfall Variability Index |
| S | Severity |

| | |
|------|---|
| SAR | Synthetic Aperture Radar |
| SCI | Statistical Centre of Iran |
| SCS | Soil Conservation Systems |
| SNHT | Standard Normal Homogeneity Test |
| SPEI | Standardised Precipitation Evapotranspiration Index |
| SPI | Standardised Precipitation Index |
| SR | Samandgan River |
| SS | Suspended Solids |
| SSFI | Standardised Streamflow Index |
| SSI | Standardised Soil Moisture Index |
| SWSI | Surface water supply index |
| SWSI | Surface Water Supply Index |
| TM | Thematic Mapper |
| UNEP | United Nations Environment Programme |
| USGS | United States Geological Survey |
| VIF | Variance Inflation Factor |
| WDS | Water-Distribution System |
| WRAP | Water Resources Approach Process |
| ZD | Zayandehrud Dam |
| ZDC | Zayandehrud Dam Catchment |
| ZR | Zayandehrud River |

PEMBANGUNAN MAP KEMARAU RISIKO ZAYANDEH RUD DAM TADAHAN AIR MENGGUNAKAN SUMBER PENDEKATAN PROSES

ABSTRAK

Tujuan utama kajian ini adalah untuk menambahbaik metodologi untuk menilai tren kemarau dan memahami kaedah yang sesuai, bergantung kepada keadaan sebenar kawasan tadahan untuk mengurangkan impak kemarau. Sebanyak 15 stesen meterologi dan 9 tolok aliran air di sekitar Tadahan Empangan Zayandehrud (ZDC), di tengah Iran telah pilih untuk dianalisa. Rangka kerja yang dipilih untuk kajian ini ialah model Proses Pendekatan Sumber Air (WRAP), satu teknik hybrid, data geologi dan morfometri di gunakan untuk lebih memahami impak dan tren kekurangan air. Penilaian index kemarau meteorologi sedia ada, iaitu Indeks Hujan Piawai (SPI), Indeks Skor Z (ZSI) dan Desil telah gunakan untuk menilai kesesuaian penentuan keadaan kemarau. Penggunaan Indeks Hujan Piawai (SPI) didapati sesuai untuk menilai kemarau meteorologi di Iran. SPI juga sesuai untuk mengenalpasti titik permulaan dan tamat sejarah kemarau. Untuk menganalisa aliran, Indeks Aliran Piawai di gunakan. Beberapa plot serak dan rajah lengkung SPI dan SSFI menunjukkan keputusan yang berkait rapat. Penilaian hujan, ujian, Mann–Kendall (MK), cerun Sene dan ujian LOWESS digunakan untuk menganggar signifikan tren temporal kedua-dua hujan dan aliran. Satu proses parametrik separa dan parametrik berkaitan dengan kaedah anggaran bergerak berintegrasi autoregresi pecahan dan ujian penskalaan MK digunakan untuk menilai signifikan tren temporal. Keputusan kajin untuk majoriti aliran siri masa berbanding hujan dalam masa kemarau menunjukkan tren selari, menunjukkan majoriti air larian pada masa susulan yang pendek dan kurang aliran penyusupan ke hilir. Kebanyakan stesen hujan dan tolok aliran menunjukkan tren meningkat. Perubahan yang tinggi berlaku di sebelah barat